

TRhizo-urbanMicrobiome

Carbon & Nitrogen Analyses

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Load Packages

Data Management

```
## Load the carbon data
carbon.data.uncleaned <- read_csv(
  file = "data/urbanMicrobiome-carbon_data.csv",
  col_types = c("fnnnn"),
  show_col_types = FALSE
)

## Load the nitrogen data
nitrogen.data.uncleaned <- read_csv(
  file = "data/urbanMicrobiome-nitrogen_data.csv",
  col_types = c("fnnnn"),
  show_col_types = FALSE
)

## Load the urbanization data
urbanization.data <- read_rds(
  file = "data/urbanization_data.rds"
)

## Combined data
carbon.nitrogen.data <- urbanization.data %>%
  full_join(carbon.data.uncleaned, by = "Population") %>%
  full_join(nitrogen.data.uncleaned, by = "Population")
```

Carbon Analyses

Soil Total Carbon

Fit the GAMs

```
## Soil total carbon
# Distance
soil.total.C.by.distance.GAM <- gam(
  Soil_Total_Carbon ~ s(Distance, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# HII
soil.total.C.by.HII.GAM <- gam(
  Soil_Total_Carbon ~ s(Human_Influence_Index, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# ISC
soil.total.C.by.ISC.GAM <- gam(
  Soil_Total_Carbon ~ s(Mean_ISC, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
```

Check Model Assumptions

```
## Soil total carbon-by-distance model diagnostics
check_model(soil.total.C.by.distance.GAM)
# Visual check = assumptions met

## Soil total carbon-by-HII model diagnostics
check_model(soil.total.C.by.HII.GAM)
# Visual check = assumptions met

## Soil total carbon-by-ISC model diagnostics
check_model(soil.total.C.by.ISC.GAM)
# Visual check = assumptions met
```

ANOVAs

Table 1: ANOVA table for the soil total carbon-by-distance GAM. Adjusted R-squared = 0.298, deviance = 35.0.

Term	EDF	Ref.df	F	P-value
s(Distance)	2.518	9	1.604	0.003

Table 2: ANOVA table for the soil total carbon-by-HII GAM. Adjusted R-squared = 0.152, deviance = 17.4.

Term	EDF	Ref.df	F	P-value
s(Human_Influence_Index)	0.859	9	0.679	0.012

Table 3: ANOVA table for the soil total carbon-by-ISC GAM. Adjusted R-squared = 0.331, deviance = 37.9.

Term	EDF	Ref.df	F	P-value
s(Mean_ISC)	2.452	9	1.867	0.001

Leaf Total Carbon

Fit the GAMs

```
## Leaf total carbon
# Distance
leaf.total.C.by.distance.GAM <- gam(
  Leaf_Total_Carbon ~ s(Distance, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# HII
leaf.total.C.by.HII.GAM <- gam(
  Leaf_Total_Carbon ~ s(Human_Influence_Index, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# ISC
leaf.total.C.by.ISC.GAM <- gam(
  Leaf_Total_Carbon ~ s(Mean_ISC, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
```

Check Model Assumptions

```
## Leaf total carbon-by-distance model diagnostics
check_model(leaf.total.C.by.distance.GAM)
# Visual check = assumptions met

## Leaf total carbon-by-HII model diagnostics
check_model(leaf.total.C.by.HII.GAM)
# Visual check = assumptions met

## Leaf total carbon-by-ISC model diagnostics
check_model(leaf.total.C.by.ISC.GAM)
# Visual check = assumptions met
```

ANOVAs

Table 4: ANOVA table for the leaf total carbon-by-distance GAM. Adjusted R-squared < 0.001 , deviance = 0.001.

Term	EDF	Ref.df	F	P-value
s(Distance)	0	9	0	0.399

Table 5: ANOVA table for the leaf total carbon-by-HII GAM. Adjusted R-squared < 0.001 , deviance < 0.001 .

Term	EDF	Ref.df	F	P-value
s(Human_Influence_Index)	0	9	0	0.814

Table 6: ANOVA table for the leaf total carbon-by-ISC GAM. Adjusted R-squared = 0.188, deviance = 23.2.

Term	EDF	Ref.df	F	P-value
s(Mean_ISC)	1.841	9	0.872	0.018

Soil Delta 13C

Fit the GAMs

```
## Soil delta 13C
# Distance
soil.delta.13C.by.distance.GAM <- gam(
  Soil_Delta_13C ~ s(Distance, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# HII
soil.delta.13C.by.HII.GAM <- gam(
  Soil_Delta_13C ~ s(Human_Influence_Index, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# ISC
soil.delta.13C.by.ISC.GAM <- gam(
  Soil_Delta_13C ~ s(Mean_ISC, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
```

Check Model Assumptions

```
## Soil delta 13C-by-distance model diagnostics
check_model(soil.delta.13C.by.distance.GAM)
# Visual check = assumptions met

## Soil delta 13C-by-HII model diagnostics
check_model(soil.delta.13C.by.HII.GAM)
# Visual check = assumptions met

## Soil delta 13C-by-ISC model diagnostics
check_model(soil.delta.13C.by.ISC.GAM)
# Visual check = assumptions met
```

ANOVAs

Table 7: ANOVA table for the soil delta 13C-by-distance GAM. Adjusted R-squared = 0.362, deviance = 38.1.

Term	EDF	Ref.df	F	P-value
s(Distance)	1.039	9	2.141	0

Table 8: ANOVA table for the soil delta 13C-by-HII GAM. Adjusted R-squared = 0.216, deviance = 23.7.

Term	EDF	Ref.df	F	P-value
s(Human_Influence_Index)	0.904	9	1.039	0.003

Table 9: ANOVA table for the soil delta 13C-by-ISC GAM. Adjusted R-squared = 0.202, deviance = 22.4.

Term	EDF	Ref.df	F	P-value
s(Mean_ISC)	0.939	9	0.954	0.004

Leaf Delta 13C

Fit the GAMs

```
## Leaf delta 13C
# Distance
leaf.delta.13C.by.distance.GAM <- gam(
  Leaf_Delta_13C ~ s(Distance, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# HII
leaf.delta.13C.by.HII.GAM <- gam(
  Leaf_Delta_13C ~ s(Human_Influence_Index, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# ISC
leaf.delta.13C.by.ISC.GAM <- gam(
  Leaf_Delta_13C ~ s(Mean_ISC, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
```

Check Model Assumptions

```
## Leaf delta 13C-by-distance model diagnostics
check_model(leaf.delta.13C.by.distance.GAM)
# Visual check = assumptions met

## Leaf delta 13C-by-HII model diagnostics
check_model(leaf.delta.13C.by.HII.GAM)
# Visual check = assumptions met

## Leaf delta 13C-by-ISC model diagnostics
check_model(leaf.delta.13C.by.ISC.GAM)
# Visual check = assumptions met
```

ANOVAs

Table 10: ANOVA table for the leaf delta 13C-by-distance GAM. Adjusted R-squared = 0.069, deviance = 8.9.

Term	EDF	Ref.df	F	P-value
s(Distance)	0.73	9	0.279	0.071

Table 11: ANOVA table for the leaf delta 13C-by-HII GAM. Adjusted R-squared = 0.011, deviance = 1.9.

Term	EDF	Ref.df	F	P-value
s(Human_Influence_Index)	0.278	9	0.043	0.247

Table 12: ANOVA table for the leaf delta 13C-by-ISC GAM. Adjusted R-squared = 0.023, deviance = 3.5.

Term	EDF	Ref.df	F	P-value
s(Mean_ISC)	0.442	9	0.087	0.191

Nitrogen Analyses

Soil Total Nitrogen

Fit the GAMs

```
## Soil total carbon
# Distance
soil.total.N.by.distance.GAM <- gam(
  Soil_Total_Nitrogen ~ s(Distance, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# HII
soil.total.N.by.HII.GAM <- gam(
  Soil_Total_Nitrogen ~ s(Human_Influence_Index, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# ISC
soil.total.N.by.ISC.GAM <- gam(
  Soil_Total_Nitrogen ~ s(Mean_ISC, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
```

Check Model Assumptions

```
## Soil total carbon-by-distance model diagnostics
check_model(soil.total.N.by.distance.GAM)
# Visual check = assumptions met

## Soil total carbon-by-HII model diagnostics
check_model(soil.total.N.by.HII.GAM)
# Visual check = assumptions met

## Soil total carbon-by-ISC model diagnostics
check_model(soil.total.N.by.ISC.GAM)
# Visual check = assumptions met
```

ANOVAs

Table 13: ANOVA table for the soil total nitrogen-by-distance GAM. Adjusted R-squared = 0.126, deviance = 14.8.

Term	EDF	Ref.df	F	P-value
s(Distance)	0.851	9	0.546	0.021

Table 14: ANOVA table for the soil total nitrogen-by-HII GAM. Adjusted R-squared = 0.006, deviance = 1.2.

Term	EDF	Ref.df	F	P-value
s(Human_Influence_Index)	0.179	9	0.024	0.278

Table 15: ANOVA table for the soil total nitrogen-by-ISC GAM. Adjusted R-squared = 0.036, deviance = 5.2.

Term	EDF	Ref.df	F	P-value
s(Mean_ISC)	0.563	9	0.141	0.142

Leaf Total Nitrogen

Fit the GAMs

```
## Leaf total carbon
# Distance
leaf.total.N.by.distance.GAM <- gam(
  Leaf_Total_Nitrogen ~ s(Distance, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# HII
leaf.total.N.by.HII.GAM <- gam(
  Leaf_Total_Nitrogen ~ s(Human_Influence_Index, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# ISC
leaf.total.N.by.ISC.GAM <- gam(
  Leaf_Total_Nitrogen ~ s(Mean_ISC, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
```

Check Model Assumptions

```
## Leaf total carbon-by-distance model diagnostics
check_model(leaf.total.N.by.distance.GAM)
# Visual check = assumptions met

## Leaf total carbon-by-HII model diagnostics
check_model(leaf.total.N.by.HII.GAM)
# Visual check = assumptions met

## Leaf total carbon-by-ISC model diagnostics
check_model(leaf.total.N.by.ISC.GAM)
# Visual check = assumptions met
```

ANOVAs

Table 16: ANOVA table for the leaf total nitrogen-by-distance GAM. Adjusted R-squared = 0.448, deviance = 49.8.

Term	EDF	Ref.df	F	P-value
s(Distance)	3.07	9	3.065	0

Table 17: ANOVA table for the leaf total nitrogen-by-HII GAM. Adjusted R-squared = 0.008, deviance = 1.4.

Term	EDF	Ref.df	F	P-value
s(Human_Influence_Index)	0.207	9	0.029	0.269

Table 18: ANOVA table for the leaf total nitrogen-by-ISC GAM. Adjusted R-squared = 0.265, deviance = 30.7.

Term	EDF	Ref.df	F	P-value
s(Mean_ISC)	1.916	9	1.364	0.003

Soil Delta 15N

Fit the GAMs

```
## Soil delta 15N
# Distance
soil.delta.15N.by.distance.GAM <- gam(
  Soil_Delta_15N ~ s(Distance, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# HII
soil.delta.15N.by.HII.GAM <- gam(
  Soil_Delta_15N ~ s(Human_Influence_Index, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# ISC
soil.delta.15N.by.ISC.GAM <- gam(
  Soil_Delta_15N ~ s(Mean_ISC, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
```

Check Model Assumptions

```
## Soil delta 15N-by-distance model diagnostics
check_model(soil.delta.15N.by.distance.GAM)
# Visual check = assumptions met

## Soil delta 15N-by-HII model diagnostics
check_model(soil.delta.15N.by.HII.GAM)
# Visual check = assumptions met

## Soil delta 15N-by-ISC model diagnostics
check_model(soil.delta.15N.by.ISC.GAM)
# Visual check = assumptions met
```

ANOVAs

Table 19: ANOVA table for the soil delta 15N-by-distance GAM. Adjusted R-squared = 0.257, deviance = 27.8.

Term	EDF	Ref.df	F	P-value
s(Distance)	0.968	9	1.306	0.001

Table 20: ANOVA table for the soil delta 15N-by-HII GAM. Adjusted R-squared = 0.216, deviance = 23.7.

Term	EDF	Ref.df	F	P-value
s(Human_Influence_Index)	0.932	9	1.521	0.001

Table 21: ANOVA table for the soil delta 15N-by-ISC GAM. Adjusted R-squared = 0.240, deviance = 26.1.

Term	EDF	Ref.df	F	P-value
s(Mean_ISC)	0.95	9	1.192	0.002

Leaf Delta 15N

Fit the GAMs

```
## Leaf delta 15N
# Distance
leaf.delta.15N.by.distance.GAM <- gam(
  Leaf_Delta_15N ~ s(Distance, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# HII
leaf.delta.15N.by.HII.GAM <- gam(
  Leaf_Delta_15N ~ s(Human_Influence_Index, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
# ISC
leaf.delta.15N.by.ISC.GAM <- gam(
  Leaf_Delta_15N ~ s(Mean_ISC, bs = "ts", k = 10),
  data = carbon.nitrogen.data,
  method = "REML"
)
```

Check Model Assumptions

```
## Leaf delta 15N-by-distance model diagnostics
check_model(leaf.delta.15N.by.distance.GAM)
# Visual check = assumptions met

## Leaf delta 15N-by-HII model diagnostics
check_model(leaf.delta.15N.by.HII.GAM)
# Visual check = assumptions met

## Leaf delta 15N-by-ISC model diagnostics
check_model(leaf.delta.15N.by.ISC.GAM)
# Visual check = assumptions met
```

ANOVAs

Table 22: ANOVA table for the leaf delta 15N-by-distance GAM. Adjusted R-squared = 0.023, deviance = 3.6.

Term	EDF	Ref.df	F	P-value
s(Distance)	0.45	9	0.09	0.188

Table 23: ANOVA table for the leaf delta 15N-by-HII GAM. Adjusted R-squared = 0.007, deviance = 1.3.

Term	EDF	Ref.df	F	P-value
s(Human_Influence_Index)	0.2	9	0.028	0.271

Table 24: ANOVA table for the leaf delta 15N-by-ISC GAM. Adjusted R-squared = 0.033, deviance = 4.8.

Term	EDF	Ref.df	F	P-value
s(Mean_ISC)	0.537	9	0.127	0.152

Save the workspace

R Session Information

Table 25: Packages required for data management and analysis.

Package	Loaded Version	Date
bayestestR	0.13.2	2024-02-12
broom	1.0.5	2023-06-09
correlation	0.8.4	2023-04-06
datawizard	0.10.0	2024-03-26
dplyr	1.1.4	2023-11-17
easystats	0.7.1	2024-03-28
effectsize	0.8.7	2024-04-01
forcats	1.0.0	2023-01-29
ggplot2	3.5.1	2024-04-23
insight	0.19.10	2024-03-22
kableExtra	1.4.0	2024-01-24
knitr	1.46	2024-04-06
lubridate	1.9.3	2023-09-27
mgcv	1.9-1	2023-12-21
modelbased	0.8.7	2024-02-15
nlme	3.1-164	2023-11-27
parameters	0.21.6	2024-03-18
performance	0.11.0	2024-03-22
purrr	1.0.2	2023-08-10
readr	2.1.5	2024-01-10
report	0.5.8	2023-12-07
see	0.8.4	2024-04-29
stringr	1.5.1	2023-11-14
tibble	3.2.1	2023-03-20
tidyr	1.3.1	2024-01-24
tidyverse	2.0.0	2023-02-22